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Structural Predictors of Lights and Sirens Use by Emergency Medical Services

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This is to certify that the doctoral study by

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Walden University
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Abstract

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MHA, Ashworth College, 2018

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Doctoral Study Submitted in Partial Fulfillment

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Doctor of Healthcare Administration

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Abstract

Ambulances regularly respond to scenes and transport patients while using lights and sirens (L&S), which are associated with an increased risk of vehicle crashes. The use of L&S persists, despite the risks, which impact emergency medical service (EMS) workers, patients, and other drivers and pedestrians on U.S. roadways. To understand the factors associated with ambulance crashes while using L&S, this study applied the Donabedian model to the problem. The purpose of this study was to investigate the association between 3 organizational structural factors—organizational type, organizational status (staffing model), and level of service—and ambulance crash rates while using L&S. This study used a quantitative, correlational, cross-sectional design with a sample drawn from the National EMS Information System data set to examine the relationship between these factors and ambulance crashes while using L&S. After application of inclusion criteria, a sample of 4,951,063 cases was drawn and analyzed using X^2 test of association and multiple logistic regression. There was a statistically significant association between level of service and ambulance crashes while using L&S, using the X^2 test of association with a small effect. There was no statistically significant relationship found between the other variables using X^2 tests or the logistic model. The organizational structural factors examined in this study failed to explain most of the variance in ambulance crash rates. EMS healthcare administrators and researchers should continue to explore potential modifiable factors to reduce the incidence of these events and promote positive social change by reducing the risk of injury to patients, EMS workers, and the public at large.

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Dedication

I dedicate this study to my son, Julian. You are my greatest joy, and with this work and those that follow it, I hope to create a better, brighter world for you to inherit. I look forward to the day when you add your own stone to the foundation that I and so many others leave for you—and I know that when your time comes, you will blow us all away.

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Section 1: Foundation of the Study and Literature Review

Introduction

Emergency medical services (EMS) is a healthcare specialty concerned with the delivery of emergency medical care to patients outside the hospital and the transport of patients to the hospital for further care (National Highway Traffic Safety Administration [NHTSA] Office of EMS, n.d.b.). EMS workers include emergency medical technicians (EMTs) and paramedics, among others; however, these two professions make up the bulk of the EMS workforce (National Association of State EMS Officials, 2020). EMTs and paramedics work in various settings, including in fire departments, hospitals, non-fire-based governmental agencies, private companies, and tribal departments, and the EMS workforce of these organizations may be paid, volunteer, or a mix of the two.

While responding to the scene of injury or illness and during transport of the patient to the hospital, ambulances often make use of their lights and sirens (L&S) to signal traffic to yield to them to expedite their journey. The reason for the rapid transport of the patient to the hospital is based on the concept of the *golden hour*, attributed to R. Adams Cowley, founder of Baltimore's Shock Trauma Institute (Roger et al., 2015). The rationale behind the golden hour is the assertion made by Cowley that a trauma patient's best chance of survival is to receive definitive care within the first 60 minutes after injury. This concept has led to an emphasis on rapid response and transport of patients by EMS agencies, despite a lack of evidence supporting it (Newgard et al., 2010).

Unfortunately, the use of L&S is not without risk. Motor vehicle accidents involving ambulances present a danger to EMS workers, patients, other ambulance passengers, occupants of other vehicles, and pedestrians. EMS workers experience higher rates of on-the-job injury than other professions, and among these events, ambulance crashes are a major contributor to injuries (Reichard et al., 2017).

Problem Statement

Previous literature has established the association between the use of L&S by EMS and increased risk of motor vehicle accidents (Watanabe et al., 2019). Between 1992 and 2011, an estimated 4,500 motor vehicle crashes involving ambulances occurred annually, with over a third of these resulting in injuries or fatalities (NHTSA, 2014a). L&S are commonly used by EMS departments to reduce the time in transit while responding to a request for service or to expedite transport of a patient to the hospital (Kupas, n.d.). The use of L&S persists despite the paucity of evidence supporting a clinical benefit of L&S for most patients treated by EMS (Murray & Kue, 2017; Tanaka & De Lorenzo, 2019).

Previous researchers have described the characteristics of L&S use by urbanicity and geographic region (Kupas, n.d.); however to my knowledge, there are no studies examining structural characteristics that may be correlated to the use of L&S or ambulance crashes. Because there are many different organizational models in the EMS industry, both within and outside the United States, it is essential to examine what, if any, role organizational context plays in the rate of ambulance crashes while using L&S. Mazen (2012) described these structural factors within the context of the Donabedian model, particularly in regard to EMS response, while the National EMS Quality Alliance (n.d.) has previously established reducing L&S use as a performance measure. This research builds on these works using the Donabedian model as a theoretical framework and examines what, if any, role organizational structure plays on ambulance crashes while using L&S.

Purpose of the Study

The purpose of this quantitative study was to investigate whether correlation exists between three structural factors of EMS departments providing 911 response in the United States and the number of ambulance crashes while using L&S; these structural factors are organizational type, organizational status, and level of service. *Organizational type* describes the overall structure of the department and includes the following levels: fire-based, governmental, nonfire, hospital, private, nonhospital, and tribal; *level of service* describes the minimum certification level provided for every request for service; and *organizational status* describes whether the agency is staffed with volunteers, nonvolunteers, or a mix of the two (National EMS Information System [NEMSIS], 2016). By understanding the relationship between organizational structure and rate of ambulance crashes while using L&S, EMS industry leaders can develop best practice models and engage in interagency information sharing to identify new methods for reducing the rate of ambulance crashes. The independent variables for this study are organizational type, level of service, and organizational status. The dependent variable for this study is rate of ambulance crashes while using L&S.

The results of this study are important for several reasons. First, they add to the understanding of factors associated with ambulance crashes, which may inform future action to intervene and create a safer environment of care for EMS workers, patients, and other drivers on the road. Second little research has been done examining structural factors and quality outcomes in EMS using the Donabedian model as a framework. This study helps identify the relationship between the structural factors identified in the levels of the independent variables and quality outcomes (in this case, rate of ambulance crashes while using L&S), which may inform future research using the Donabedian model in EMS.

Research Questions and Hypotheses

RQ1: Is there a statistically significant difference in ambulance crashes while responding or transporting with lights and sirens by organizational type (fire department, governmental, nonfire, hospital, private, nonhospital, tribal)?

$H_0$1: There is no statistically significant difference in ambulance crashes while responding or transporting with lights and sirens by organizational type.

H_a1: There is a statistically significant difference in ambulance crashes while responding or transporting with lights and sirens by organizational type.

RQ2: Is there a statistically significant difference in ambulance crashes while responding or transporting with lights and sirens by organizational status (mixed, nonvolunteer, volunteer)?

$H_0$2: There is no statistically significant difference in ambulance crashes while responding or transporting with lights and sirens by organizational status.

H_a2: There is a statistically significant difference in ambulance crashes while responding or transporting with lights and sirens by organizational status.

RQ3: Is there a statistically significant difference in ambulance crashes while responding or transporting with lights and sirens by level of service (EMT-basic, EMT-paramedic)?

$H_0$3: There is no statistically significant difference in ambulance crashes while responding or transporting with lights and sirens by level of service.

H_a3: There is a statistically significant difference in ambulance crashes while responding or transporting with lights and sirens by level of service.

Theoretical Foundation for the Study

The Donabedian model describes three healthcare quality measures: structure, process, and outcome (Donabedian, 1988). While *structure* indicates the "conditions under which care is provided" (Donabedian & Bashshur, 2003) and includes organizational characteristics and other factors that make up the context or setting of care delivery, *process* refers to all the healthcare are performed (i.e., taking blood pressure or inserting an intravenous line), while *outcome* refers to the results of healthcare delivery. Within the context of EMS, structure can include facilities, staffing, credentials, deployment, and other characteristics of the system (Mazen, 2012), and it is factors within this performance measure that I used as the independent variables in this study.

Transport with or without L&S is a process measure within the framework of the Donabedian model. As noted above, the benefit of L&S transport to patients is disputed (Murray & Kue, 2017); however, the National EMS Quality Alliance (n.d.) has set reducing L&S use as a target performance measure. Therefore, I used rate of ambulance crashes while using L&S as my dependent variable.

Nature of the Study

In this study, I used a quantitative, correlational approach using a cross-sectional design with secondary data made up of electronic health records (EHRs) available through NEMSIS. The dependent variable was ambulance crashes while responding to or transporting from scene using L&S and measured on the categorical, nominal scale. Within the NEMSIS data set, the variables needed to obtain the dependent variable were additional response descriptors, additional transport descriptors, type of response delay, and type of transport delay (the latter of which includes the level *vehicle crash involving this unit*, which I used to obtain my rate of ambulance crashes). In contrast, independent variables included organizational type, level of service, and organizational status and were also measured on the categorical, nominal scale.

Secondary Data Types and Sources of Information

Secondary data came from the NEMSIS data set. This data set contains EHRs from EMS departments in participating states. No other sources of data were used for this study. The data set includes EHRs from over 10,000 EMS agencies in 47 states and territories of the United States, and includes over 34 million EHRs (NEMSIS, n.d.). An appropriate sample and effect size for this study are discussed in Section 2.

Literature Search Strategy

I conducted a literature review using Sage Journals, ProQuest Central, Public Administration Abstracts, ScienceDirect, Directory of Open Access Journals, Emerald Insight, Embase, CINAHL, and PubMed for the following keywords: *emergency medical service or EMS or paramedic or prehospital care, organizational type or service delivery* *model*, *level of service*, *basic life support*, *advanced life support*, *organizational status*, *volunteer, ambulance crashes*, and *lights and sirens*. The literature review was limited to peer-reviewed articles published within the last 5 years, except where the only relevant sources did not meet that criteria. Articles were selected based on relevance to the topic and variables of my study.

Literature Review Related to Key Variables and/or Concepts

The purpose of this literature review is to provide an exhaustive review of the current literature related to the variables of interest, methodology, and rationale to justify this study's relevance within the context of what is already known about the problem. For this review, I synthesized studies about ambulance crashes while using L&S (dependent variable), organizational type, level of service, and organizational status (independent variables). There is considerable interest in the influence of structural factors in EMS quality outcomes. Howard et al. (2018) identified 331 quality indicators and assigned each a category within the Donabedian framework. These measures included clinical indicators, such as those related to trauma, stroke, and cardiac arrest, as well as nonclinical indicators like time intervals, service user satisfaction, resource deployment, and financial indicators. Below, I discuss what is already known in the literature about each of the variables as well as their relevance to this study.

Organizational Type

Organizational type is a variable described in the NEMSIS data set (n.d., p. 17) as "The organizational structure from which EMS services are delivered (fire, hospital, county, etc.)." In 2011, fire-based EMS agencies were the single most reported organizational type (40%; NHTSA, 2014b), followed by private non-hospital-based (25%), governmental, and non-fire-based (21%). EMS in the United States originated between 1960 and 1973, as a collection of unregulated, disorganized systems delivered by a variety of service providers, including hospitals, fire departments, morgues, and volunteer groups (Shah, 2006). The seminal publication of the comprehensive report titled *Accidental Death and Disability: The Neglected Disease of Modern Society* (National Academy of Sciences—National Research Council, 1966) identified the lack of a formal EMS system as a contributor to morbidity and mortality related to motor vehicle crashes on U.S. highways. In turn, this spurred the development of formal training programs and a regulatory framework governing EMS and helped to standardize the industry (Shah, 2008). Despite these advances, the delivery of EMS care remains, in many ways, disjointed, with many different organizational types providing ambulance services in the United States (40%; NHTSA, 2014b).

Influence on Work Behaviors

While the report by the National Academy of Sciences–National Research Council helped to standardize the EMS industry by creating a framework for minimum service standards, there remain many variations in how services are delivered in the different types of organizations, such as those associated with hospitals, fire departments, and other volunteer programs. To understand how organizations influence outcomes and work behavior, Borry and Henderson (2020) examined the impact of organizational and individual factors on rule-breaking behaviors in EMS. Borry and Henderson noted that organizational rules (i.e., policies, protocols, standard operating guidelines) come in multiple levels of formality and that EMS workers often deviated from rules. Furthermore, Borry and Henderson found that organizational factors can influence employee behavior to engage in rule breaking for perceived prosocial reasons. In their study, Borry and Henderson identified an ethical climate as a significant and inverse predictor of rule-breaking behavior, with a one-unit increase in ethical climate, reducing the chances of engaging in rule breaking by 66%. Unfortunately, the authors did not analyze the differences in rule-breaking behavior by organizational type.

Common EMS Organizational Types

The three most common EMS organization types are (a) fire-based (40%); (b) private, non-hospital-based (25%); and (c) governmental, non-fire-based (21%) (NHTSA, 2014b). Fire-based models are operated as part of a fire department, with fire department civilian employees operating solely as EMS providers or cross-trained staff serving dual roles as both EMS providers and firefighters (International Association of Fire Chiefs, n.d.). Even when ambulance services are provided by other organizational types (i.e., hospital-based, governmental, non-fire-based), fire departments often provide EMS first response (nontransport medical services) in conjunction with the ambulance provider.

Governmental non-fire-based agencies are another form of publicly owned EMS model, operating as a third-service distinct and independent from fire or police departments (Federal Emergency Management Agency, 2012). These organizations contrast with for-profit or nonprofit commercial companies providing EMS. Both governmental non-fire-based and private EMS organizations are distinct from fire-based services in that their primary organizational function is the provision of EMS. Private

EMS agencies may provide nonemergent services (such as interfacility transport), emergent transport, or a combination of both.

EMS Organization Influence on L&S Use

Understanding organizational influence on worker behavior is important to identify what, if any, influence organizational type has on the rate of ambulance crashes while using L&S. Previous researchers have found an association between the use of L&S and ambulance crashes (Watanabe et al., 2019); therefore, organizational controls to limit the use of L&S may help reduce the rate of ambulance crashes. These organizational controls are important because, as Tennyson et al. (2015) found, in the absence of standardized rules about the use of L&S by EMS organizations, EMTs and paramedics will disregard their knowledge about the risks associated with the use of L&S. Their conclusions were supported by Borry and Henderson (2020) who found that organizational controls are an important mediator of the use of L&S by EMS agencies. These results also align with Borry's (2017) examination of the relationship between organizational structure and ethical climate on rule-breaking behavior. Borry identified three ethical climates, including organizational interest, team interest, and rules/standard operating procedures that significantly influenced rule breaking. The question becomes, what are the differences in organizational type in EMS?

Differences in Quality Outcomes by Organizational Type

A study by Redliner et al. (2018) examined the differences in organizational type in EMS. Redliner et al. examined the adoption of quality metrics in the United States, finding that hospital-based EMS departments were more likely to track quality measures when compared to fire-based departments (OR 2.49, 95% CI 1.36, 4.59) and that rural departments were less likely to follow quality metrics (OR 0.47, 95% CI 0.31, –0.72%, $p < 0.0004$). Other researchers have also found differences in practice variation based on organizational type. Govindarajan et al. (2012) conducted a descriptive study of EMS agencies participating in the Cardiac Arrest Registry to Enhance Survival and noted that fire-based agencies made up the greatest share of participating agencies (43%), followed by governmental third-service (non-fire) based agencies. Although Govindarajan et al. found variation in practice among the EMS agencies surveyed, they did not provide descriptive statistics on these metrics by organizational type.

Studnek and Ferketich (2007) examined differences between organizational type and quality outcomes. The researchers surveyed EMTs, asking them to describe their seatbelt use and found that a lack of organizational policy on seatbelt use was associated with lower seatbelt use compared to agencies that had a policy. The results of this study are consistent with the learnings from previous research. Furthermore, the researchers also concluded that employees of government or military organizations reported the highest prevalence of seat belt use (93.6%), compared to hospital-based or fire-based organizations (82.1% and 82.5%, respectively). The researchers also found that EMS organizational type was significantly associated with the presence of a seatbelt policy or not ($p < 0.0001$).

Summary of Organizational Types

In summary, organizational factors, including organizational type, have been associated with differences in worker behaviors in the EMS industry. These factors have been associated with differences in quality outcomes (clinical and non-clinical), including differences in L&S use. Therefore, organizational type may also predict rates of ambulance crashes while using L&S.

Level of Service

Level of service is a variable described in the NEMSIS data set (n.d.) as "The level of service which the agency provides EMS care for every request for service (the minimal certification level). This may be the license level granted by the state EMS office." EMTs, advanced emergency medical technicians (AEMTs), and paramedics are the most commonly and consistently licensed levels of EMS providers in the U.S. (National Association of State EMS Officials, 2020). EMTs make up 63% of the EMS workforce, followed by paramedics (31%) and AEMTs (6%). EMTs receive approximately 100-110 hours of total training, compared to 300-400 for AEMTs, and 1,000-2,000 for paramedics (Remick et al., 2014). This education includes clinical components such as anatomy & physiology, pharmacology, and pathology, as well as non-clinical components, including operations and emergency vehicle operation (EVO).

The NHTSA Office of EMS *National EMS Education Standards* (n.d.) states that EMTs, AEMTs, and paramedics should all have "simple depth, foundational breadth" of knowledge related to the risks and responsibilities of transport with regards to the principles of safely operating a ground ambulance. This document indicates that the expected level of knowledge for paramedics for this component should be the same as EMTs. While some educational programs may provide additional education beyond what is required by the Office of EMS, it is not required.

Level of Service and EVO Safety

No studies to my knowledge have looked at the rate of ambulance crashes while using L&S by level of service; however, several have looked at EVO by level of service. Cash et al. (2019) examined EVO safety practices in EMS and found an association between the license level of the EMS worker and seatbelt use. Using multivariable logistic regression, they determined that paramedic licensure was associated with decreased odds of consistent seatbelt use compared to EMTs [AOR 0.61, 95% CI 0.46, 0.81]. These results are consistent with those found by Studnek & Ferketich (2007), whose study found that EMTs are more likely than paramedics to wear their seatbelts. Other studies have found an association between license level and EMS operations, such as the work by Price (2018), which examined these variables with time on scene.

A study by Watanabe et al. (2019) included level of service in their primary data analysis; however, it was not a primary variable of investigation. Nevertheless, they found that agencies at the paramedic level of service reported that 76.0% of their responses and 22.2% of transports were with L&S (compare to EMT, 78.4%, and 31.7%, respectively). Watanabe et al. (2019b) also found that an EMT level of service agency was statistically significantly more likely to use L&S inappropriately compared to a paramedic level of service (52% vs 36%).

Summary of Levels of Service

There are several takeaways from this section about levels of service. First, national education standards support an equivalent level of education on EVO regardless of level of service (EMT vs. paramedic). This suggests that EMTs and paramedic—at least during their foundational training—are equally educated on the principles of EVO. Nonetheless, several studies have indicated differences in vehicle safety operations by level of service. While EMTs are more likely to wear seatbelts, they are also more likely to use L&S while transporting patients. Paramedics have much higher educational standards than EMTs and can perform more invasive procedures, including the administration of medications to patients. Therefore, EMTs may have a stronger motivation to expedite transport of the patient to the hospital for more advanced care when compared to paramedics, who are more often able to deliver advanced care to the patient on scene or during transport.

Organizational Status (Staffing Model)

Organizational status is a variable described in the NEMSIS data set (n.d., p. 16) as “The primary organizational status of the agency. The definition of Volunteer or Non-Volunteer is based on state or local definitions”. In the NHTSA’s national assessment of the EMS workforce (2008), the authors calculated an estimated 272,746 licensed volunteer providers in 2003. Mears (as cited in NHTSA, 2008) determined that 46.6% of the EMS workforce across all license levels of 44 reporting states were volunteers in 2003, with an average of 73% in the 12 most rural states. The distribution of volunteer providers was higher in low-volume, rural services as well as individual states who reported most of their EMS providers were volunteers. The NHTSA (2014b) EMS System Demographics assessment reported that one-third of states indicated that most EMS agency staff were volunteers.

Characteristics of Staffing Models

EMS agencies in urban areas typically use paid staff, while those located in more rural areas more frequently use a volunteer or mixed staffing model (Federal Emergency Management Agency, 2012; Mears, as cited in NHTSA, 2008). Mixed staff services use a combination of paid and volunteer employees to staff ambulances and respond to requests for service. Freeman et al. (2009) noted that literature on EMS workforce concerns is limited but highlighted that EMS work is physically and emotionally taxing, fraught with the risk of injury and exposure to disease, poorly paid, and has expensive educational barriers to entry. These inherent factors play a role in EMS recruitment and retention; however, they influence recruitment differently between urban and rural areas and between the level of license. As the authors noted, rural EMTs were less likely to report financial considerations and career opportunities as part of their reasons for working in EMS compared to paramedics. Furthermore, they found that the time commitment and training requirements were the most cited barriers to volunteering.

Challenges for Different Staffing Models

While EMS agencies using paid staff can often maintain consistent staffing levels, volunteer agencies may experience inconsistency in staffing, which can stress system resources and require that they depend on adjacent agencies to provide coverage for service requests. Worker retention is challenging for paid services as well, and there are large disparities in compensation across the U.S. In a study by Studnek (2016), the author found that organizational type was a major source of earnings disparity, with employees of fire-based EMS agencies earning significantly more than employees of other organizational types. This is important because Rivard et al. (2020) found that a desire for better pay was an important reason for paramedics deciding to leave the EMS industry.

Workforce and Outcomes

Research on organizational status (staffing model) in EMS is limited. Studnek & Ferketich (2007) found that volunteer EMS agencies had a higher odds ratio (OR) of seatbelt use than other organizations [OR 0.53, CI 95% 0.43, 0.64] and determined that agencies that reported no organizational seatbelt policy had a lower odds of reporting high seatbelt use, thus linking organizational intervention to outcomes. A study by Redliner (2018), however, found that agencies with paid or mixed staff were more likely to follow clinical metrics when compared to volunteer services. They also found that agencies with dedicated quality staff were more likely to track quality measures, positions that budget-constrained volunteer agencies may not be able to afford. While this study was specific to clinical quality measures, it may have applications to non-clinical quality measures (including vehicle safety outcomes) as well.

Ambulance Crashes While Using L&S

The dependent variable for this study is rate of ambulance crashes while using L&S. Ambulance crashes present a hazard to EMS workers, patients, passengers, and other drivers on the roadways, and contribute to thousands of vehicular crashes in the United States. (NHTSA, 2014a). As previously discussed, the use of L&S has long since been associated with ambulance crashes (Watanabe et al., 2019). L&S are typically used to expedite ambulance response to the scene of injury or illness or during transport of the patient to the hospital (Kupas, n.d.). A comprehensive review by Murray & Kue (2017) questioned the clinical benefit of the time saved by L&S (Murray & Kue, 2017). Bertholet et al. (2020), however, found a statistically significant benefit to the time saved by L&S transport for patients being “fast-tracked” to certain care modalities, specifically, patients experiencing an ST-elevated myocardial infarction (STEMI) or stroke.

Scope of L&S Transport and Ambulance Crashes

In an analysis by the NHTSA (2014a), there were 4,500 motor vehicle crashes involving ambulances between 1992 and 2011. While less than 1% of these resulted in fatalities, 34% resulted in an injury—an annual mean of 29 fatal ambulance crashes and 33 fatalities per year. Occupants of other vehicles were most likely to be killed (63%), followed by ambulance passengers (21%), non-occupants (12%), and the driver of the ambulance (4%). Injury patterns were similar, with 54% involving occupants of other vehicles, 29% being ambulance passengers, and 17% being the driver the ambulance. 58% of fatal ambulance crashes and 59% of injury crashes involved the use of L&S.

Human Impact

The National Institute for Occupational Safety and Health (n.d.) records and publishes injury data on non-fatal injuries among EMS workers. The most recent available year with data on these injuries was 2013, which recorded 2,200 (11%) transportation incidents. This statistic is the number of EMS workers who were treated in emergency departments for any injury involving transportation vehicles, which includes (but is not limited to) ambulance crashes. While not specific to the variable of interest, this number does demonstrate the significant human toll of transportation incidents on the EMS workforce.

Factors Associated With Ambulance Crashes

EVO requires skill and attentiveness to do safely. Weaver et al. (2015) that drivers of ambulances use reaction time and judgment to operate these vehicles safely, and that fatigue impairs drivers in a manner similar to alcohol intoxication, increasing the risk of a crash 8-fold. Their study showed that EMS workers average only 6 hours of sleep before prolonged shifts of 12 hours or more. Folk & Tucker (2003) demonstrated that the relative risk of injury associated with shift work was not static; instead, it increases progressively from morning to afternoon and night and is compounded by successive nights of work. The overall length of the shift and minutes since the last break also resulted in increased relative risk.

Summary of Ambulance Crashes While Using L&S

Overall, there is strong support in the literature that the use of L&S is associated with ambulance crashes. The human cost of ambulance crashes includes injuries and deaths involving ambulance occupants, occupants of other vehicles, and non-vehicle occupants, with the latter of these sharing the greatest burden. Despite conflicting evidence regarding the clinical benefit of using L&S and the inclusion of reducing L&S use, it remains a common practice.

Gaps in Literature

As a highly specialized subset of healthcare, which developed relatively recently compared to the practices of medicine and nursing, EMS and paramedical science are emerging areas of scientific inquiry. Research is limited, and many of the practices of the industry lack scientific support (Cone, 2007). Although several organizations are collecting descriptive data on EMS agencies and events such as ambulance crashes in the U.S., our understanding of how organizational factors affect operations or the application of theory to these outcomes is limited. This study adds to our understanding of these events in two ways: first, it applies a theoretical approach to this topic. Second, it is—to my knowledge—be the first to evaluate the association between organizational factors and ambulance crashes critically.

Literature Review Summary

Previous literature has described the scope and human impact of ambulance crashes while using L&S. The descriptive statistics of ambulance crashes are metrics of interest to organizations at multiple levels, including individual EMS agencies, professional associations, and state and national governing bodies. Human factors that are associated with rates of ambulance crashes have been described in detail, such as the impact of fatigue on cognitive function; however, organization-level factors, including those of interest to this study, are less well understood.

Regarding these organizational factors, historical works have primarily focused on descriptive statistics detailing industry demographics, such as the number of EMS agencies by type (i.e., fire-based, hospital-based, etc.) in the U.S. or the percent of volunteer vs. paid services. The relationship between these variables and outcome measures is less well described, and previous literature has focused more on clinical outcomes than operational measures. Despite these unknowns, the Donabedian model and its general applicability to EMS has been described in the literature and has been applied in research on organizational factors and their effect on rule compliance in EMS.

Definitions of Terms

Ambulance crash: A motor vehicle accident involving the responding ambulance. Identified in the data set under two variables: Type of Response Delay and Type of Transport Delay (NEMSIS, n.d.).

EMS agency: An agency authorized by a state governing body to deliver emergency medical care and ambulance transport. EMS agency is identified in the data set under the variable Primary Type of Service and will include only those providing 911 response with transport capability (NEMSIS, n.d.).

EMS worker/provider: An individual licensed by a state EMS governing body to provide emergency medical care in the out-of-hospital setting. For this study, an EMS worker/provider shall refer to one of the two license levels of interest: EMT or paramedic. These levels are identified in the data set as EMT-Basic and EMT-Paramedic (NEMSIS, n.d.).

Level of service: The minimum license level of at least one of the EMS providers on every EMS response (NEMSIS, n.d.). The values of interest in this study are EMT-Basic and EMT-paramedic.

Lights and sirens (L&S): The visual and audible warning systems used by emergency vehicles. The use of L&S is identified in the data set under the variables Additional Response Descriptors and Additional Transport Descriptors (NEMSIS, n.d.).

Organizational status: The primary organizational status of the agency (NEMSIS, n.d.). This is the staffing model of the agency, and the levels of this variable are mixed, non-volunteer, and volunteer.

Organizational type: The service delivery model of the EMS agency (NEMSIS, n.d.). This includes fire-based (or fire department), governmental, non-fire, hospital, private, non-hospital, and tribal.

Assumptions

There are several assumptions I made for this study. EMS is regulated by numerous agencies at the state and federal levels (Cordi & Goldstein, 2019), and there is no standard definition for organizational types or organizational statuses (staffing models). Therefore, there may be differences in organizational type or organizational status (staffing model), even when agencies report the same values for these variables. Level of service is governed by license level, which is regulated at the state level; however, there is a federal scope of practice model which provides a national framework for license level (NHTSA, 2019). Furthermore, certification through the National Registry of Emergency Medical Technicians (NREMT) is a requirement for initial licensure in most U.S. states (NREMT, n.d.), thereby assuring a minimum expectation of training in most of the country.

Another assumption is that all ambulance crashes that occurred within the timeframe studied were recorded in the data set. The final assumption is that the use of L&S was accurately recorded in the values of the variables additional response descriptors and additional transport descriptors. Previously literature has used the data elements response mode to scene and transport mode from scene to determine if L&S were used (Watanabe et al., 2019); however, different elements were chosen for this study because they may more accurately reflect whether L&S were actually used by the responding ambulance.

Limitations

To my knowledge, there are no fees associated with the acquisition of the data set. However, there may be a delay in obtaining the data following submission of a request; if the request for data is denied, this would represent an insurmountable barrier to this study, and I would have to develop a new topic entirely. There may be unforeseen challenges in terms of completeness of the data; however, given the large sample within the data set, I do not expect having adequate data to be a challenge. There are no other expected limitations to this study currently.

Scope and Delimitations

The scope of this study is quantitative and correlational, and the conclusions are limited by the validity of the data set used (NEMSIS). The independent variables of organizational type, organizational status (staffing model), and level of service were selected because of the literature gap previously identified. These variables fit within the framework of the Donabedian model (Mazen, 2012) and are already recorded in the NEMSIS data set, thereby facilitating this research.

This study analyzed the electronic health records of participating EMS agencies in the NEMSIS data set in 2019. Only electronic health records where all four variables were recorded were included for statistical analysis. The generalizability of this study is limited to EMS agencies providing ground ambulance transport with EMT and paramedic staff using one of the organizational types indicated in the variable. EMS agencies providing first response but not transport and air medical EMS agencies are not included in this study.

Significance, Summary, and Conclusions

The results of this study contribute to the existing body of knowledge of healthcare administration in the EMS environment in several meaningful ways. This study will inform EMS administrators of the relationship, if any, between organizational factors and the rate of ambulance crashes while using L&S. EMS organizational models are structurally different from one another, and some of these departments have other missions beyond the delivery of healthcare services (e.g., firefighting) when compared to standalone EMS agencies, which may overlap or conflict. Conversely, independent EMS departments may lack the external support of large fire service unions and governmental agencies like the National Fire Protection Agency (NFPA) to provide resources and tools or to engage in research on the impact of organizational context and EMS outcomes or to rely on for best practices and other resources. Lastly, varying levels of education and organizational support are structural factors that may impact safe driving practices by EMS workers.

While EMS workers are generally aware of the risks related to L&S, they do not engage in behaviors to limit their use in the absence of external controls (i.e., protocols) (Tennyson et al., 2015). This indicates that organizational structural factors influence the use of L&S in EMS agencies in the form of policies and protocols and may be more important than behavioral (process) factors in controlling the use of L&S. These organizational factors have been previously implicated in operational outcomes in the

EMS setting (Studnek & Ferketich, 2007), but, to date, to my knowledge, there are no studies that have individually analyzed their role in ambulance crashes while using L&S.

The results of this study will inform industry leaders of the role, if any, of local-level department configuration on the rate of ambulance crashes while using L&S and promote positive social change by empowering leaders with knowledge on the relationship between these factors and the safety of workers, patients, and bystanders on the roadways during emergency ambulance operations. This study addresses both a literature and practice gap that has implications for EMS workers, agency administrators, patients, and other drivers and pedestrians on U.S. roads. The human impact of ambulance crashes touches employee health, patient safety, and roadway safety, and reflects how EMS truly stands at the crossroads of healthcare, public safety, and public health. In the following section, I discuss the research design and methodology for this study, explaining the rationale for my approach and how it aligns with the foundation of this study.

Section 2: Research Design and Data Collection

Introduction

As established in Section 1, ambulance crashes present a danger to EMS workers, the patients they treat, and other drivers and pedestrians on U.S. roadways. The Donabedian model is the theoretical framework used for this study. Under the Donabedian model, quality outcomes are the product of system factors such as process and structure (Donabedian, 1988). Within the scope of this study, I evaluated the relationship between structural factors and the rate of ambulance crashes while using L&S.

In this section, I describe the research design and rationale and the methodology I used to analyze the data statistically. In this study, I used a single source of data, the NEMSIS data set, to isolate the sample using specific inclusion criteria, and then I statistically analyzed all variables using the appropriate tests. I have attempted to control threats to the study's validity, both internal and external. Where I was unable to control for these factors, I accounted for them, recognizing that this study is only one more piece in the existing body of knowledge regarding the topic of ambulance crashes.

Research Design and Rationale

In this study, I used a quantitative, correlational, cross-sectional design with secondary data available in the NEMSIS data set. The independent variables for this study are organizational type, organizational status (staffing model), and levels of service. The dependent variable for this study is ambulance crashes using L&S. The research questions I examined are specific to the relationship and association between the independent and dependent variables. I selected statistical tests that best describe and examine that relationship. Because I used secondary data that are publicly available, there are no specific time or resource constraints I needed to account for. Lastly, because of the research questions I selected, this research design—specifically, a quantitative approach using secondary data available in an extensive publicly available database—was most suited for this endeavor.

Methodology

Population

The target population for this study was ambulance runs for EMS agencies with transport capability available in the NEMSIS data set for the calendar year 2019. I analyzed all the EHRs in the data set for 2019 that met the criteria. There were 19,040,095 ambulance runs for 911 requests of service that used L&S and 2,539 ambulance crashes in 2016 (Watanabe et al., 2019); therefore, I conservatively estimated a sample size of around 19,000,000 cases.

Sampling and Sampling Procedures

To obtain an appropriate sample for this research study, I selected cases that met the inclusion criteria identified in Table 1. These filters limited the cases included in the sample to those from EMS agencies that provide 911 response and transport of patients to the hospital, providing either EMT or paramedic-level service. Cases were drawn only from 911 requests for service, and I included only those ambulance runs where L&S were used (either responding to the scene or during transport). Cases that did not meet these inclusion criteria or that had missing values for any of the variables of interest were excluded from statistical analysis.

Table 1

Inclusion Criteria for Sampling Procedure

Data element number	Data element name	Value code	Value description
dAgency.09	Primary type of service	9920001	911 Response (scene) with transport capability
dAgency.11	Level of service	9917011	EMT-basic
		9917015	EMT-paramedic
dAgency.12	Organizational status	1016001	Mixed
		1016003	Nonvolunteer
		1016005	Volunteer
dAgency.13	Organizational type	9912001	Fire department
		9912003	Governmental, non-fire
		9912005	hospital
		9912007	Private, nonhospital
		9912009	Tribal
dAgency.15	Statistical calendar year	Integer	2019
eResponse.05	Type of service requested	2205001	911 Response (scene)
eResponse.24	Additional response descriptors	2224015	Lights and sirens
eDisposition.18	Additional transport descriptors	4218011	Lights and sirens

All data for this study were retrieved from the NEMSIS data set. NEMSIS includes data on over 34 million EMS activations from 10,062 EMS agencies serving 47 states and territories (NEMSIS Technical Assistance Center [TAC], 2020). The NEMSIS data set is a large convenience sample provided by participating EMS agencies, and deficiencies originating from contributing parties are carried over into the NEMSIS data, though the NEMSIS TAC works to improve the quality of the data by checking for completeness, consistency, and formatting. Data that fail the NEMSIS TAC’s validation processes are removed or flagged, and a quality report is provided to the sending agency. Nonetheless, selection bias exists based on the convenience sample, which is made up of voluntarily submitted EHRs.

The NEMSIS data set is organized into a set of relational tables and consists of 42 files provided in ASCII format, SAS, and STAT formats (NEMSIS TAC, 2020). These files can be converted into other formats, including SPSS. I completed and submitted a request form (see Appendix A) to NEMSIS to access the data set (NEMSIS, n.d.).

Power Analysis

To determine the sample size, I conducted an a priori power analysis using G*Power, a free power analysis calculator. To determine effect size, I referenced the adjusted ORs (AOR) cited by Watanabe et al. (2019) for crash rate with any L&S [AOR 2.90, 95% CI 2.18, 3.87] and the adjusted OR of ambulance crashes while transporting with L&S for private EMS agencies [AOR 5.3, 95% CI 3.9, 7.3]. Based on the results of the power analysis, the required sample size was be 202.

Table 2

*Logistic Regression Power Analysis Using G*Power*

Input	Tail(s)	2
	Odds ratio	1.83
	Pr (Y = 1|X = 1) H1	0.84
	Pr (Y = 1|X = 1) H0	0.74
	α value	0.05
	Power	0.95
Output	Sample size	202
	Actual power	0.95

Operationalization

Independent Variables

The three independent variables for this study—organizational type, organizational status (staffing model), and level of service—exist as discrete variables in the NEMSIS data set (NEMSIS, n.d.). These variables are measured on the categorical (nominal) level and are readily available for analysis. The operational definitions for these variables are as follows:

Organizational Type. "The organizational structure from which EMS services are delivered (fire, hospital, county, etc.)" (NEMSIS, n.d.).

Level of Service. "The level of service which the agency provides EMS care for every request for service (the minimum certification level). This may be the license level granted by the state EMS office" (NEMSIS, n.d.).

Organizational Status. "The primary organizational status of the agency. The definition of volunteer or non-volunteer is based on state or local definitions" (NEMSIS, n.d.).

Dependent Variable

The dependent variable for this study is ambulance crashes using L&S. This is not a discrete variable within the NEMSIS data set, but rather a single, dichotomous variable that was created using four discrete variables in the data set. The operational definition of these variables are as follows:

Ambulance Crash Using L&S. A motor vehicle accident involving the responding ambulance. This dichotomous variable was created based on the values of two elements in the data set: type of response delay and type of transport delay. (NEMSIS, n.d.). A value of vehicle crash involving this unit for either of these elements in the NEMSIS data set equates to a Yes for the dependent variable of this study. If there is any other value for both elements in the NEMSIS data set, this translates to a value of No in the dependent variable. See Table 2.

Table 3

Data Type for Each Study Variable

NEMSIS data element	NEMSIS data value	Dependent variable value Ambulance crash using L&S
Type of response delay And/or Type of transport delay	Vehicle crash involving this unit	Yes
Type of response delay And Type of transport delay	Any other data value.	No

Table 3 shows all four variables of interest in this study as well as their corresponding data elements from the NEMSIS data set and the level of measurement. All four variables were measured on the categorical (nominal) scale, with one dichotomous and two polytomous independent variables and one dichotomous dependent variable. All three independent variables already exist as discrete data elements in the NEMSIS data set (NEMSIS, n.d.); the dependent variable was created based on two existing elements in the data set.

Table 4

Data Type for Each Study Variable

Variable name	Data element	Data type
Independent variables		
Organizational type	Organizational type	Categorical (polytomous)
Organizational status (staffing model)	Organizational status	Categorical (polytomous)
Level of service	Level of service	Categorical (dichotomous)
Dependent variable		
Ambulance crashes using L&S	Type of response delay Type of transport delay	Categorical (dichotomous)

Data Analysis Plan

Before analyzing the data, I collected a sample from the data set applying the filters indicated in Table 1. Afterward, I created a new element in the data set, Ambulance Crashes Using L&S, which was categorical and dichotomous and based on the logic presented in Table 2. I considered leaving the original elements (type of response delay and type of transport delay) for frequencies data, but ultimately elected not to. These elements were not part of my statistical analysis.

Research Questions and Hypotheses

RQ1: Is there a statistically significant difference in ambulance crashes while responding or transporting with lights and sirens by organizational type (fire department; governmental, non-fire; hospital; private, non-hospital; tribal)?

H01: There is no statistically significant difference in ambulance crashes while responding or transporting with lights and sirens by organizational type.

Ha1: There is a statistically significant difference in ambulance crashes while responding or transporting with lights and sirens by organizational type.

RQ2: Is there a statistically significant difference in ambulance crashes while responding or transporting with lights and sirens by organizational status (mixed, non-volunteer, volunteer)?

H02: There is no statistically significant difference in ambulance crashes while responding or transporting with lights and sirens by organizational status.

Ha2: There is a statistically significant difference in ambulance crashes while responding or transporting with lights and sirens by organizational status.

RQ3: Is there a statistically significant difference in ambulance crashes while responding or transporting with lights and sirens by level of service (EMT-basic, EMT-paramedic)?

H03: There is no statistically significant difference in ambulance crashes while responding or transporting with lights and sirens by level of service.

Ha3: There is a statistically significant difference in ambulance crashes while responding or transporting with lights and sirens by level of service.

Statistical Analysis

The data were analyzed with IBM SPSS Statistics 25. To analyze the data, I performed two statistical tests: cross-tabulation with chi-square (χ^2) and multiple logistic regression. Cross-tabulation using the χ^2 statistic provided univariate frequency distribution of each of the variables. At the same time, logistic regression explained the relationships between the independent variables and the dependent variable, controlling for the effect of one variable while examining the effect of the other (Agresti, 2013). Cramer's V and OR were the measures of effect, and the alpha for both χ^2 and logistic regression was set at 0.05.

Logistic regression is a non-parametric test that analyses the relationship between multiple independent variables (also known as predictors) on a dependent variable (Hilbe, 2009). This test estimates an OR for the model predictors within the context of the logistic model. Applying the study variables to a logistic regression model where b0 is the intercept, b1 is the slope coefficient for each variable of interest (i.e., X1, X2, …, etc.) and e is the sample errors/residuals and estimates of ε (errors), we develop the following model:

$$\text{logit}(Y \text{ (Ambulance Crashes Using L\&S)}) = b_0 + b_1X_1 \text{ (Organizational Type)} + b_2X_2 \text{ (Organizational Status)} + b_3X_3 \text{ (Level of Service)} + e$$

Threats to Validity

External Validity

The NEMSIS data set includes cases from 10,062 EMS agencies serving 47 states and territories (NEMSIS TAC, 2020), which aids in the generalizability of the results of this study. This equates to 47% of all 21,283 licensed EMS agencies in 2011 (NHTSA, 2014b). Nevertheless, as previously established, the independent variables in this study are predominantly regulated at the state and local level, which means that their values may not uniformly translate from state to state or even from city to city. While this may limit the overall generalizability of the results of this study, the large sample size and the high percent of EMS agencies represented in the data set across most of the U.S. should help to neutralize some of those differences. Furthermore, the strong national framework created by the NHTSA Office of EMS and other national organizations has provided a largely standardized framework to the U.S. EMS system.

Internal Validity

Numerous factors impact driving ability, including fluctuations in the level of fatigue and vigilance (Chiara et al., 2020). Other factors, such as road and weather conditions, driver experience, and the driving ability of other drivers may also lead to motor vehicle crashes. Many of these factors are difficult to quantify, and none have been recorded in the data set, and therefore, cannot be controlled. Additionally, within the context of the Donabedian model, structure is considered an indirect measure of quality that is difficult to relate to outcomes (Mazen, 2011). Unfortunately, this cannot be accounted for, but the large sample size may help to offset the impact of them on the model.

Ethical Procedures

The NEMSIS data set is not population-based, but rather event-based. Each case represents a single EMS response rather than an individual patient EHR NEMSIS TAC, 2020). A patient may request EMS service multiple times, and therefore would be represented in the data set numerous times as well. Because the research topic of this study is concerned with EMS activations and ambulance crashes that occurred during those activations, there was no need for any patient identifiable information in this analysis. Furthermore, the data set does not contain information that identifies patients, EMS agencies, receiving hospitals, or reporting states (NEMSIS, n.d.).

Summary

As detailed above, the quantitative, correlational, cross-sectional design of this study was best suited to explain the relationship between the independent and dependent variables according to the research questions. The NEMSIS data set is the most appropriate source of secondary data, being a representative of nearly half of all licensed EMS agencies in the U.S. (NEMSIS TAC, 2020). Furthermore, the statistical tests, namely the X2 and logistic regression, provided a robust examination of the associations between these variables. While there are several threats to the validity of this study, this design minimized the impact of these where possible and did so within the limits of the available data. The results of this study will inform healthcare leaders in the EMS industry of the role of organizational structural factors on ambulance crashes while using L&S. Section 3 provided the statistical findings of my data analysis within the context of the research topic.

Section 3: Presentation of the Results and Findings

Introduction

The purpose of this study was to examine the relationship between EMS organizational structural factors and ambulance crashes while using L&S within the framework of the Donabedian model. The three organizational factors I used as my independent variables were organizational type, organizational status (staffing model), and level of service. EMS agencies employ many different organizational models (NHTSA, 2014b) with substantial differences in the overall structure of the organizations based on these unique organizational factors. For example, because paramedics have a greater scope of practice than EMTs, maintaining an agency at the paramedic level of service requires the purchase and management of medications and additional equipment. Likewise, fire-based EMS agencies must contend with maintaining an entire set of equipment, policies, and processes unrelated to and alongside the delivery of healthcare services. To understand the relationship between these variables and ambulance crashes while using L&S, I investigated three research questions, which are listed below, along with their associated hypotheses.

RQ1: Is there a statistically significant difference in ambulance crashes while responding or transporting with lights and sirens by organizational type (fire department; governmental, non-fire; hospital; private, non-hospital; tribal)?

$H_0$1: There is no statistically significant difference in ambulance crashes while responding or transporting with lights and sirens by organizational type.

H_a1: There is a statistically significant difference in ambulance crashes while responding or transporting with lights and sirens by organizational type.

RQ2: Is there a statistically significant difference in ambulance crashes while responding or transporting with lights and sirens by organizational status (mixed, non-volunteer, volunteer)?

H_02: There is no statistically significant difference in ambulance crashes while responding or transporting with lights and sirens by organizational status.

H_a2: There is a statistically significant difference in ambulance crashes while responding or transporting with lights and sirens by organizational status.

RQ3: Is there a statistically significant difference in ambulance crashes while responding or transporting with lights and sirens by level of service (EMT-basic, EMT-paramedic)?

H_03: There is no statistically significant difference in ambulance crashes while responding or transporting with lights and sirens by level of service.

H_a3: There is a statistically significant difference in ambulance crashes while responding or transporting with lights and sirens by level of service.

Data Collection of Secondary Data

Obtaining Data, Time Frame, and Discrepancies of the Data Set

After receiving approval by the Walden University Institutional Review Board (IRB) (#09-04-20-1004319), I placed a request for the publicly available data through the NEMSIS TAC. The data were provided in one thumb drive and a digitally transferred set of data, each containing several SAS files, which I converted to SPSS format.

Unexpectedly, rather than a single data set containing all the variables, each of the SAS files included two variables: a unique PCRKey and a second, discrete data element from the data set. The PCRKey serves as the case identifier, allowing variables to be matched to the correct case across the various files of data. This did, however, require the merging of several files in SPSS to form a unique data set that met the inclusion criteria of my study. Also, contrary to my initial plan, the data set I received was for the 2019 calendar year. This was a minor change that does not affect the study or its validity in any way; the change was reported to and approved by the IRB. All statistical analyses were completed using IBM SPSS Statistics Version 25.

Descriptive Statistics

After applying my inclusion (Table 1) and exclusion criteria and building a unique data set from the various SAS files I received, I obtained a sample size of 4,951,063. This was much higher than the required sample size determined by the a priori power analysis of 202 with a power of 0.95, alpha = 0.05, effect size (OR) = 1.83, but lower than my initial estimate. There were no cases from agencies with an organizational type of tribal. After filtering all cases according to the inclusion criteria noted above, there were 207 ambulance crashes while using L&S identified in the data set.

Table 5

Descriptive Statistics: Organizational Type, Organizational Status, Level of Service, and Ambulance Crashes Using L&S

Variable	Characteristic	Frequency	Valid percentage
Independent variables			
Organizational type	Fire department	2,000,048	40.4
	Governmental, non-fire	1,091,993	22.1
	Hospital	267,629	5.4
	Private, nonhospital	1,591,393	32.1
	Tribal	–	–
Organizational status (staffing model)	Mixed	897,855	18.1
	Nonvolunteer	3,963,855	80.1
	Volunteer	89,288	1.8
Level of service	EMT	348,290	7.0
	Paramedic	4,602,773	93.0
Dependent variable			
Ambulance crashes using L&S	Yes	207	.0
	No	4,950,856	100.0

Results

To analyze the study variables, I obtained frequency statistics and then performed crosstabulations and Pearson’s chi-square test of association for each of the independent variables. The chi-square test of association tests the strength of association between two categorical variables (Rajaretnam, 2016). This test assumes that there are two variables measured at the categorical level, observations are independent, and all cells should have expected counts greater than five. Next, I conducted logistic regression analyzing the relationship between all four variables.

Research Question 1

The χ^2 test of association is a nonparametric test for variables with categorical values (Connelly, 2019). It is used to compare the distribution of values in one variable with those of another to determine whether variables are independent. If the distribution of one variable is not different between groups, we can conclude there is independence between these variables (the null hypothesis); if the reverse is true, then we would determine that these variables are associated with one another (the alternative hypothesis).

There are several measures to choose from to determine effect size, including Phi (ϕ), Cramer’s V, and OR. While Cramer’s V can be used for larger tables, the use of ϕ and OR should be limited to 2x2 contingency tables (Kim, 2017). For all cross tabulations performed in this study, Cramer’s V is the appropriate measure of effect size.

Cramer’s V is defined as

$$V = \sqrt{\frac{\varphi^2}{t}} = \sqrt{\frac{X^2}{nt}}$$

where “t is the smaller of the number of rows minus one or the number of columns minus one” (Gingrich, 1992, p. 782). This measure, therefore, corrects for differences in the size of the table being analyzed. Cramer’s V can thus be used to compare the strength of association between any two tables, where a stronger relationship is indicated by a higher value of Cramer’s V. Cramer’s V can be used for both 2x2 tables as well as larger ones. When used for 2x2 tables, Cramer’s V has the same value as ϕ. Table 8 (adapted from Kim, 2017) indicates the effect size based on the value of Cramer’s V according to the degree of freedom.

Table 6

Effect Size for Cramer's V and Interpretation

Degree of Freedom	Small	Medium	Large
1	0.10	0.30	0.50
2	0.07	0.21	0.35
3	0.06	0.17	0.29
4	0.05	0.15	0.25
5	0.04	0.13	0.22

Table 7

Cross Tabulation: Organizational Type by Ambulance Crash While Using L&S

Variable	Characteristic	Ambulance crash while using L&S			
		Yes		No	
		n	%	n	%
Organizational type	Fire department	84 (.1)	40.6	1,999,964 (-.1)	40.4
	Governmental, nonfire	48 (.4)	23.2	1,091,945 (0.4)	22.1
	Hospital	13 (.6)	6.3	267616 (–.6)	5.4
	Private, nonhospital	62 (–.7)	30.0	1,591,331 (.7)	32.1
	Tribal	–	–	–	–

Table 8

Pearson's Chi-Square Test Results: Organizational Type by Ambulance Crash While Using L&S

	Value	Df	Asymptotic significance (2-sided)
Pearson chi-square	.724	3	.867
Likelihood ratio	.715	3	.870
Linear-by-linear association	.170	1	.680
N of valid cases	4,951,063		

I conducted a χ^2 test of association between organizational type and ambulance crash while using L&S. All expected cell frequencies were greater than the minimum expected count of 11.19. There was not a statistically significant association between organizational type and ambulance crash while using L&S, $\chi^2(3) = .724$, $p = .867$. The adjusted standardized residuals were less than 2 for all categories, indicating that the cell counts were close to expected by the null hypothesis (Agresti, 2013).

There was no association between organizational type and ambulance crash while using L&S was small, based on Cramer's V (Kim, 2017).

Table 9

Cramer's V

	Value	Approximate significance
Phi	.000	.867
Cramer's V	.000	.867
N of valid cases	4,951,063	

Research Question 2

I conducted a χ^2 test of association between organizational status (staffing model) and ambulance crash while using L&S. All expected cell frequencies were greater than the minimum expected count of 3.73, and one cell had less than 5 counts. There was not a statistically significant association between organizational status (staffing model) and ambulance crash while using L&S, $\chi^2(2) = .150$, $p = 0.928$. The adjusted standardized residuals for all cells were less than 2, indicating that the cell counts were close to expected by the null hypothesis (Agresti, 2013).

There was no association between organizational status (staffing model) and ambulance crash while using L&S, based on Cramer's V (Kim, 2017).

Table 10

Cross-Tabulation: Organizational Status (Staffing Model) by Ambulance Crash While Using L&S

Variable	Characteristic	Ambulance crash while using L&S			
		Yes		No	
		n	%	n	%
Organizational status (staffing model)	Mixed	38 (.1)	18.4	897,882 (–.1)	18.1
	Nonvolunteer	166 (.0)	80.2	3,963,689 (.0)	80.1
	Volunteer	3 (–.4)	1.4	89,285 (.4)	1.8

Table 11

Pearson's Chi-Square Test Results: Organizational Status (Staffing Model) by Ambulance Crash While Using L&S

	Value	Df	Asymptotic significance (2-sided)
Pearson chi-square	.150	2	.928
Likelihood ratio	.160	2	.923
Linear-by-linear association	.024	1	.877
N of valid cases	4,951,063		

Table 12

Cramer's V

	Value	Approximate significance
Phi	.000	.928
Cramer's V	.000	.928
N of valid cases	4,951,063	

Research Question 3

I conducted a χ^2 test of association between Level of Service and ambulance crash while using L&S. All expected cell frequencies were greater than the minimum expected count of 77.59. There was a statistically significant association between ambulance crash while using L&S, $\chi^2(1) = 4.224$, $p = 0.040$. The adjusted standardized residuals for all cells were greater than 2, indicating that the cell counts were not as expected by the null hypothesis (Agresti, 2013).

There was a small association between Level of Service and ambulance crash while using L&S, based on Cramer's V (Kim, 2017).

Table 13

Cross-Tabulation—Level of Service by Ambulance Crash while Using L&S

Variable	Characteristic	Ambulance crash while using L&S			
		Yes		No	
		n	%	n	%
Level of service	EMT	7 (–2.1)	3.4	348,283 (2.1)	7.0
	Paramedic	200 (2.1)	93.0	4,602,573 (–2.1)	93.0

Table 14

Pearson's Chi-Square Test Results: Level of Service by Ambulance Crash While Using L&S

	Value	Df	Asymptotic significance (2-sided)
Pearson chi-square	4.224	1	.040
Likelihood ratio	5.162	1	.055
Linear-by-linear association	4.224	1	.023
N of valid cases	34,203,087		

Table 15

Cramer's V

	Value	Approximate significance
Phi	.001	.040
Cramer's V	.001	.040
N of valid cases	4,951,063	

Logistic Regression

To analyze the strength of the relationship between the variables, I performed logistic regression. Logistic regression is the regression model best suited for handling categorical variables (Rajaretnam, 2016), and is used to model the probability of an event's occurrence using a logit function. The logistic regression assumes that the dependent variable is dichotomous, that there are one or more independent variables measured at the continuous or nominal level, that observations are independent, and that there should be a minimum of 10-20 cases per independent variable (Stoltzfus, 2011).

To determine effect size, I measured OR. OR is a widely used measure of association for logistic regression (Hosmer et al., 2013), where the measure's value indicates the degree of association between the variables. For example, let us assume that we are considering the association between the use of seatbelts and surviving motor vehicle crashes. A value of 1 would indicate equivalency of associations (equal odds of surviving a crash whether you wear a seatbelt or not). A value of 2 would indicate that the odds of surviving a crash are twice that for those who wear seatbelts vs. those that do not.

Conversely, values of less than 1 indicate fractional values. In the previous example, an OR of 0.5 indicates that the odds of surviving a crash while wearing a seatbelt are half the value of those who do not wear a seatbelt. OR is provided by SPSS while performing logistic regression as the exponentiation of the B coefficient (Exp(B)) and reported as such.

Table 16

Logistic Regression Test Results

	B	SE	Wald	df	p	OR	95% CI for OR	
							Lower	Upper
Organizational type			.331	3	.954			
Fire department (1)	.020	.175	.014	1	.907	1.021	.724	1.438
Governmental, nonfire (2)	.068	.195	.122	1	.727	1.070	.730	1.568
Hospital (3)	.155	.206	.258	1	.612	1.168	.641	2.128
Private, nonhospital (reference)	–	–	–	–	–	–	–	–
Tribal	–	–	–	–	–	–	–	–
Organizational status (staffing model)			.001	2	.999			
Volunteer (1)	–.020	.588	.001	1	.973	.981	.310	3.104
Mixed (2)	–.001	.187	.000	1	.998	.999	.693	1.442
Nonvolunteer (reference)	–	–	–	–	–	–	–	–
Level of service								
EMT (1)	–.752	.391	3.699	1	.054	.471	.219	1.014
Paramedic (reference)	–	–	–	–	–	–	–	–

I conducted binomial logistic regression to determine the effects of organizational type, organizational status (staffing model), and level of service on Ambulance Crashes while Using L&S. The logistic model showed adequate goodness of fit as assessed by the Hosmer and Lemeshow test (p = .562) and was not statistically significant $X^2(6) = 5.489$, p = .483. The model explained .1% of the variance in Ambulance Crashes while Using L&S (Nagelkerke R^2) and correctly classified 100% of cases.

Summary

In this section, I presented the results and findings of the statistical analyses I performed, including descriptive and inferential statistics. Descriptive statistics supported the validity of the sample based on the a priori power analysis discussed in section 2 and included cross-tabulations and X^2 tests of association for each of the independent variables by the dependent variable. Inferential statistics included the application of a logistic regression model to determine the strength of the association between these variables. Section 4 describes the interpretation of the results, limitations of the study, and implications and recommendations for professional practice.

Section 4: Application to Professional Practice and Implications for Social Change

Introduction

In this correlational, quantitative, cross-sectional study, I examined the relationship between organizational structural factors and their association with ambulance crashes in the United States for the 2019, calendar year using secondary data from the NEMSIS data set. In Section 3, I reviewed the research questions of interest as well as the statistical methods I used to analyze these. Descriptive statistics were provided, demonstrating the overall robustness of the data set, with a total sample of 4,951,063, following the application of the inclusion criteria (Table 1). This sample size met the requirements of the a priori power analysis discussed in Section 2.

Due to an absence of any cases with tribal listed as their organizational type, this category was not represented in statistical analysis. All other categories were described within the data set after the application of the inclusion criteria. Of the cases selected for inclusion in this study, there were 207 ambulance crashes noted for an overall rate of 4.18 crashes while using L&S per 100,000 ambulance runs, which is slightly less than the rate of 5.4 per 100,000 ambulance runs established in previous studies (Watanabe et al., 2019).

To analyze the data, I provided descriptive statistics and applied inferential tests using IBM SPSS Statistics 25. X^2 tests of association failed to establish a statistically significant relationship between the variables for RQ1 and RQ2, and the null hypothesis was retained. However, tests did show a statistically significant association between level of service and ambulance crashes while using L&S; therefore, the null hypothesis was rejected in favor of the alternative hypothesis. The effect of this association was small, based on the value of Cramer's V (Kim, 2017). Logistic regression failed to establish a statistically significant relationship between the independent and dependent variables; therefore, the null hypothesis was retained.

Interpretation of the Findings

RQ1: Organizational Type by Ambulance Crash While Using L&S

The X^2 test of association failed to establish a relationship between the independent and dependent variables ($p > .05$); therefore, $H_0 1$ was retained.

RQ2: Organizational Status by Ambulance Crash While Using L&S

The X^2 test of association failed to establish a relationship between the independent and dependent variables ($p > .05$); therefore, $H_0 2$ was retained.

RQ3: Level of Service by Ambulance Crash While Using L&S

The X^2 test of association established a statistically significant relationship between the independent and dependent variables ($p < .05$); therefore, $H_0 3$ is rejected, and the $H_a 3$ is accepted. This is further supported by the values of the adjusted standardized residuals of > 2 (Agresti, 2013). While there was a statistically significant result from this test, the effect size was small based on the value of Cramer's V (Kim, 2017).

Logistic Regression: Analysis

The results of the logistic regression model failed to establish a statistically significant association between the independent and dependent variables ($p > .05$);

therefore, the $H_0$3 was retained. Overall, the model had a poor fit and failed to reach statistically significant results for any independent variables.

Findings to Literature

To my knowledge, this is the first study in which the researcher examined the relationship between organizational structural factors and ambulance crashes using the Donabedian model as a theoretical framework. Previous researchers have established the validity of this model and its application to the EMS setting; however, few have explored this in practice. The results of my study are consistent with other work explaining the overall weak effect of structure on quality outcomes (Mazen, 2012), with only one of my statistical tests demonstrating a statistically significant result.

Overall, the results of this study suggest that the organizational structural factors assessed in this study are not strongly associated with ambulance crashes while using L&S. As previously established in the literature, safe ambulance operation depends on many different skills, including drive attentiveness, reaction time, and driver judgment (Weaver at al., 2015). Given that various organizations use a variety of staffing models, there may be organizational structural factors that do influence these events, such as level of training, shift length, and policies on fatigue mitigation and EVO. If so, it does not appear that the implementation of these falls across the lines of organizational type, organizational status (staffing model), or level of service provided by the EMS agency.

Organizational Type

NHTSA (2014b) described the three most common EMS organization types as fire-based (40%); private, non-hospital-based (25%); and governmental, non-fire-based

(21%). The descriptive statistics of my study largely coincided with these (Table 5). Organizational type was not identified in the literature as an independent variable in other studies related to ambulance crashes; my study, then, is the first to examine the relationship between these variables. The results of my analyses failed to demonstrate a statistically significant relationship between organizational type and ambulance crashes while using L&S.

Organizational Status (Staffing Model)

Previous research has linked organizational status (staffing model) to variation in seatbelt use (Studnek & Ferketich, 2007) and quality outcomes (Redliner, 2018). My study failed to demonstrate any association between this variable and ambulance crashes. This suggests that, while differences in staffing models may influence operational and quality outcomes in some instances, our understanding of the role of this variable is incomplete. The results of my study add to an already inconsistent picture of the role of organizational status on EMS outcomes.

Level of Service

Level of service was the only independent variable in this study whose analysis reached statistical significance. The effect of this was small, however, suggesting that the role of level of service is minimal in its association with ambulance crashes. Previous studies have demonstrated a statistically significant association between the license level of EMS workers and seatbelt use (Cash et al., 2019), with paramedics having a decreased odds of consistent seatbelt use compared to EMTs. Interestingly, my study demonstrated decreased odds of being involved in an ambulance crash while using L&S for EMT level services [OR .471, 95% CI .219, 1.014].

Ambulance Crashes While Using L&S

As identified by Watanabe et al. (2019), the use of L&S has been demonstrably associated with ambulance crash rates. My study did not attempt to revalidate Watanabe et al.'s work, but to address a noted gap in the literature. Of note and as previously stated, the overall rate of crashes while using L&S for my study was 4.18 per 100,000 compared to the rate of 5.4 per 100,000 found by Watanabe et al. The reason for this difference is likely due to the variation in sampling techniques.

Findings to Theory

As discussed in section 1, the Donabedian model describes three healthcare quality measures: structure, process, and outcome (Donabedian, 1988). This study assessed the influence of three structural factors on ambulance crashes while using L&S. The findings of this study failed to establish a strong association between structure and ambulance crashes while using L&S. Mazen (2012) stated that a limitation of structure within the Donabedian model was its weak association with quality outcomes, and the results of this study support that. Ultimately, the primary drivers of ambulance crashes may be process factors, such as the use of L&S, driver competence, and ability, as well as external factors beyond our control like weather and road conditions.

Summary of Key Findings and Interpretation

The quantitative outcomes of this study did not demonstrate a statistically significant relationship between two of the three organizational structural factors assessed and ambulance crashes. The only relationship that achieved statistical significance was the X^2 test of association between level of service and Ambulance Crashes while Using L&S; however, the effect of this result was small. Logistic regression failed to establish a relationship between the independent and dependent variables. Overall, the results of this study indicate that organizational type and organizational status (staffing model) do not influence ambulance crashes and level of service exerts a small but statistically significant influence on ambulance crashes. Within the framework of the Donabedian model, there may yet be structural elements of interest, such as the presence or absence of policies on EVO, fatigue mitigation processes, driver competencies, etc.

Limitations of the Study

There are several limitations associated with this study. First, this study used a convenience sample of data provided by NEMSIS. The limitations of the data set, therefore, remain inherent to the results of the study. For example, not all ambulance crashes may have been recorded in the medical record. Alternatively, the use of L&S may have been inaccurately recorded in some of the variables.

Additionally, the inclusion criteria for this study (Table 1), limit its applicability to EMS agencies whose organizational type is not represented in the data set, as well as those that provide a different level of service (e.g., AEMT, nursing, physician, etc.). The sample was also specific to those services providing 911 response with transport capabilities; therefore, agencies that only offer EMS first response or inter-facility transport were not represented. All cases with missing values were excluded from statistical analysis to ensure the most reliable data for the study.

Recommendations

This was a quantitative study using secondary data from the NEMSIS data set. While a careful selection of the variables of interest was made beforehand, the data set has several limitations. For example, while I posited that organizational structure may influence factors such as policy and organizational support for employee and patient safety activities, the acceptance of all but one of the null hypotheses in this study suggests that, if structural factors do play a role in ambulance crashes, they are not unique to the independent variables I assessed. Future research should evaluate the role of specific policies, employee competencies, and other specific organizational interventions to reduce or moderate the incidence of ambulance crashes in their agencies. Given the relative infrequency of these events, however, may necessitate alternative approaches to examining the role of structure on ambulance crashes within the framework of the Donabedian model.

Implications for Professional Practice and Social Change

It is my hope that the results of this study will positively influence professional practice and social change within the EMS industry. In this study, I demonstrated that organizational type and organizational status (staffing model) had no effect on ambulance crashes. Level of service had a small but statistically significant association with ambulance crashes. This study demonstrates to healthcare leaders within the EMS field that these macroscopic organizational characteristics may not play a major role in operational outcomes. This should empower leaders to cross interdisciplinary lines and collaborate to identify what, if any, organizational structures and processes can be influenced to reduce the rate of ambulance crashes.

Professional Practice

As discussed in section 1, ambulance crashes present a risk to EMS workers, patients, and their families, as well as pedestrians and other drivers on the road (Reichard et al., 2017). These events can lead to injury or death of patients, employees, and other members of the public, resulting in lawsuits, lost worker hours, damage or destruction of vehicles and equipment, as well as damage to the agency's professional reputation and other direct and indirect costs. Fortunately, this study provides further evidence that these events are rare, but, unfortunately, it failed to identify any major modifiable factors to reduce the rate of crashes. Instead, the results support what the literature has previously demonstrated: these events are the culmination of errant and uncontrollable processes and circumstances, and thus, difficult to control. Watanabe et al. (2019) demonstrated the relationship between the use of L&S and ambulance crashes, and this may be the most important modifiable factor in reducing the incidence of crashes.

James Reason introduced the concept of the Swiss cheese model of accident prevention in 1990, which asserts that layers of prevention exist between an adverse event and decisions by organizational leaders and that accidents occur when the holes of these layers align (Musgrove, 2019). The implications of this concept have been widely applied to patient safety principles (Stein & Hess, 2015). They may apply to the incidence of ambulance crashes in the out-of-hospital environment as well. If this is true, there is no silver bullet to preventing these incidents, nor macroscopic deterministic organizational features. Instead, these structural factors may only serve as extra layers of prevention that work in concert with processes like the use of disuse of L&S and external circumstances such as the weather, all of which ultimately lead to or avoid disaster.

Social Change

For EMTs and paramedics, disaster is always just a few moments away, whether it is the disaster they are responding to or the potential disaster they may encounter while operating emergency vehicles. Ambulance crashes and transportation incidents remain a major contributor to injury to EMS workers and the patients they treat (NHTSA, 2014a). This study adds to the body of knowledge regarding these events and may help direct future research towards modifiable factors—whether they are organizational or process-oriented. The first pledge in the Code of Ethics set forth by the National Association of Emergency Medical Technicians (n.d.) states: "To conserve life, alleviate suffering, promote health, do no harm, and encourage the quality and equal availability of emergency medical care." EMS workers are in a unique position to harm not only to their patients but to their coworkers and even the public at large. For this reason, the continued scientific study of ambulance crashes and interventions to reduce their incidence is not only a patient safety goal but a social change goal as well.

Conclusion

This study was a quantitative evaluation that addressed the literature gap around the role of three organizational structural factors on ambulance crashes while using L&S. The factors evaluated included organizational type, organizational status (staffing model), and level of service. The results of my analyses indicate that only the level of service has a statistically significant but small association with ambulance crashes. While the results of this study did not reveal any modifiable organizational factors that could be used to reduce the rate of ambulance crashes, it did provide an additional and unique level of understanding about this complex and important problem. EMS healthcare administrators should continually assess their agency's preparedness for these types of events and to take precautionary action to intervene before a crash occurs, and to investigate the causes of crashes after the fact. The information learned from this study will help assist these leaders in that investigation by asserting the non-role of the macroscopic organizational factors studied. Additionally, these results will help guide future research in determining what modifiable factors may be of interest in reducing ambulance crash rates in the industry. While we are unlikely ever completely to eliminate these types of accidents, further research may help make the industry safer for EMS workers, their patients, and the public at large.

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Appendix: Research Request Form

NEMSIS Research Request Form

Public Use National EMS Database

Please use this form to request a copy of the 2019 Public Use National EMS Database.

If you are a person or representative of an organization interested in using the Public Use National EMS Database for research purposes only, please fill out the section below and snail-mail (or e-mail to nemsis@hsc.utah.edu with an electronic signature) to the NEMSIS Technical Assistance Center for approval. Please note, if you are specific concerning the description of the research, it will improve our ability to facilitate access to the database. The database will be made available to you through a mailed thumb drive.

Thank you.

TERMS OF USE

Please be advised of the following Terms and Conditions of Use. In order to request the NEMSIS dataset, you must agree to these terms and conditions (below), completely fill out the data application form and sign it.

The National Highway Traffic Safety Administration (NHTSA) established the NEMSIS Dataset as a public service to be a repository of EMS related data voluntarily reported by participating EMS agencies and states. **Please note that the NEMSIS dataset is not a complete population-based dataset.**

The National Highway Traffic Safety Administration, through the NEMSIS TAC, collects and maintains the NEMSIS Dataset. Therefore, use of any information from this database must include a prominent credit line. That line is to read as follows:

National Highway Traffic Safety Administration (NHTSA), National Emergency Medical Services Information System (NEMSIS). The content reproduced from the NEMSIS Database remains the property of the National Highway Traffic Safety Administration (NHTSA). The National Highway Traffic Safety Administration is not responsible for any claims arising from works based on the original Data, Text, Tables, or Figures.

Specific Terms of Agreement:

Limited license is granted to use said information from the NEMSIS Database from the National Highway Traffic Safety Administration, provided the Requester agrees to the following provisions:

- Treat the information received from the NEMSIS Technical Assistance Center as non-public health data. The data may never be used by Requester as a basis for legal, administrative or other actions that can directly affect an individual whose medical or personal information is identifiable in the data.

- Use the information received under the provisions of this Agreement only for the following not-for-profit purposes: research, advocacy, medical education, patient education, or other EMS care-related activities supported by not-for-profit organizations.
- All Information derived from the NEMSIS National EMS Database shall remain the full property of The National Highway Traffic Safety Administration and shall be so noted in educational material, website presentations, and publications.
- Warrant that The National Highway Traffic Safety Administration is not responsible for any claims arising from works based on the original Data, Text, Tables, or Figures.
- Indemnify the National Highway Traffic Safety Administration and the National EMS Information System Technical Assistance Center and their employees and agents from any and all liability, loss, or damage suffered as a result of claims, demands, costs, or judgments arising out of use of NEMSIS National EMS Database information.
- Requestor may not sublease or permit other parties to use NEMSIS data without advance written approval of NEMSIS Technical Assistance Center.

The Requester's obligations hereunder shall remain in full force and effect and survive the completion of the Requester's defined project described herein above. The terms of this Agreement shall be binding upon the Requester and the organization through which his/ her project is conducted.

A copy of the final printed material must be forwarded to NEMSIS Technical Assistance Center staff.

N. Clay Mann, PhD, MS, MBA
NEMSIS Technical Assistance Center
295 Chipeta Way, P.O. Box 581289
Salt Lake City, Utah 84158-1289

If you have read and agree to comply with the above Terms of Use, please provide the following information, sign in the space provide and mail the original with signature to the above address. This form may be e-mailed to nemsis@hsc.utah.edu if an electronic signature is attached to the document.

Signature:		Date:	

Print Full Name:

Mailing Address:

City:

State: Zip Code:

Phone:

Email:

Organization(s) Represented:

Purpose of Research

Hypothesis/Question to be answered:

Data format to be used: Please indicate preference as either SAS, STATA, or ASCII (pipe-delimited) format.

Analysis to be used:

Known limitations associated with the NEMSIS sample:

Plans for Publication:

Project Sponsor: